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Furnace for the Treatment of Flowing Reaction Partners

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of December 2, 1949, is claimed.

Currently tube furnaces are often used for catalytic treatment of flowing, especially liquid reaction partners and in particular in a reaction furnace of the tube type, in which flowing reaction partners can be treated in a safe and efficient way under the conditions of high pressure and high temperature.

Currently tube furnaces are often used for catalytic and non-catalytic treatment of flowing reaction partners and in particular for the treatment of flowing hydrocarbons. To promote the different reactions in the reaction tubes of these tube furnaces, temperatures ranging from 800 to

1100 deg are often necessary. To minimize the possibility of the tubes rupturing or bursting in the heating chamber, the technology has generally found it necessary to date to work essentially at atmospheric pressure, i.e. in the range of, for example, 0 to 1 kg / cm^2 pressure in the hottest part of the tube. After prolonged use of the reaction tubes of tube furnaces, it was found that they rupture or burst even at such low pressures subject to the affect of such factors as shape and layout stresses, structural changes in the metals used, especially the preferred austenitic metals; factors in connection with the operation, e.g. delivery of high temperature flame or combustion gases to the tube wall and local combustion as a consequence of the preceding coking, and impact stresses owing to the presence of undesired condensates, generated during boiling or startup.

If one or several reaction tube(s) burst(s) or rupture(s) in operation at high temperature and low pressure, the result is that the escaping gases burn in the combustion chamber around the tubes. This combustion at low pressure is generally inadequate to induce significant danger or even significant damage to the neighboring tubes. At high pressure and high temperature, however, the rate at which tubes burst or rupture increases. Moreover, at high pressure, tube ruptures are more likely to occur in the form of a violent blow out, which can severely damage the entire furnace and can represent a danger for the operating personnel. Furthermore, under high pressure the reaction tubes themselves contain more gas; and the system contains on both the inlet and outlet end of the reaction tubes large amounts of pressurized fluid, which are ready to flow out when a tube ruptures.

In light to this and other dangers when working under high pressure and at high temperature, the technology has avoided conducting such reactions in tube furnaces to date, especially if the temperature or the pressure or both could not be held relatively low. For example, high pressure coils or rows of tubes have been used successfully to refine petroleum, for which process the tube temperatures are usually held below 650 deg., for example. Under such conditions the breaking stress of the metal guarantees a useful service life of the device. In the meantime ruptures still continue to occur even in this case; and the source of danger is always present, despite the strength of the metal that is used. In contrast to petroleum refining, tube temperatures ranging from about 815 to 1,000 deg. are usually required for catalytic cracking of petroleum and other flowing hydrocarbons for the recovery of hydrogen. Some reactions are conducted efficiently at tube temperatures of 1,100 deg., for which temperatures practically no breaking stress data are available in order to form a basis for designing a safe and satisfactory pressure apparatus. As a result, the technology has decided that, as a consequence of the high potential danger of tube ruptures and the resulting dangers, pressures, which are significantly above atmospheric pressure, shall be avoided as impractical and dangerous for conducting high temperature reactions in tube furnaces. In the absence of any solution to the problem, this recognition has had the impact of blocking the development of technology in the field of high pressure high temperature reactions of flowing reaction partners in the preferred tube reaction furnace.

However, a high pressure high temperature system has, in fact, many advantages that would be very attractive if such a system could be operated efficiently without significant danger. For example, many reactions require the use of pressurized synthesis gas as the reaction partner. In the current state of the art it is necessary to produce the synthesis gas first in tube furnaces and then to compress it to the desired pressure. In the direct isolation of pressurized synthesis gas from natural gas, the general practice is to react the gas with oxygen at a pressure ranging from

14 to 21 kg / cm^2 in a pressure chamber, which is insulated in the interior, in order to convert it to a pressurized synthesis gas. This process requires a high investment in the pressure system and the use of expensive oxygen or an expensive method for producing oxygen.

If the conditions of high pressure and high temperature were to be applied simultaneously in a tube reaction furnace, pressurized synthesis gas could be produced directly by reacting pressurized natural gas or other flowing hydrocarbons with water vapor, carbon dioxide or another oxygen-containing gas. Expensive oxygen recovery systems could be avoided. Since the flowing hydrocarbon could be introduced into the reaction tube at a selected pressure, significantly above the atmospheric pressure, a subsequent compression of the generated gas could be omitted or at least significantly reduced. Furthermore, all advantages associated with conducting reactions at raised pressure and raised temperatures could be realized. The result would be significantly greater effects, because under the conditions of high pressure and high temperature the reaction rate is increased while simultaneously retaining the same heating surface.

The object of the invention is to provide a tube reaction furnace, in which flowing reaction partners, in particular flowing hydrocarbons, can be treated catalytically or non-catalytically with greater efficiency and safety under the conditions of high temperature and high pressure. Another goal of the invention is such a tube reaction furnace, in which more than one flowing reaction partner can be treated simultaneously or separately.

In general the invention presents a tube reaction furnace for the treatment of pressurized, flowing reaction partners. Said furnace comprises the union of a heating chamber; at least one oblong metallic reaction tube in the heating chamber; at least one outer metallic tube, which is arranged around at least the essential part of each reaction tube in the region of highest stress inside the heating chamber, said outer tube being designed flow-tight in relation to the reaction tube and the heating chamber; inlet means for delivering pressurized flowing reaction partners to each reaction tube and outlet means for removing the pressurized reaction products from each reaction tube. Similarly this invention includes a method for the treatment of flowing reaction partners under conditions of high temperature and high pressure. Said method consists of sending flowing reaction partners through a reaction zone at a pressure that is significantly above atmospheric pressure, introducing a substantially inert gas into an encasement zone, which is arranged flow-tight around the reaction zone, and heating the reaction zone to a predetermined temperature by means of heaters arranged flow-tight outside the encasement zone. Preferably the substantially inert gas is held at a pressure significantly above the atmospheric pressure, but below the pressure of the flowing reaction partners in the reaction zone.

The furnace, according to the invention, can contain a single reaction tube inside each outer tube or a plurality of reaction tubes, which are arranged concentrically or separated from one another and the wall of the outer tube. Preferably both the outer tubes and the inner reaction tubes run completely through the heating chamber. However, it is also within the scope of this invention that both the outer tube and the inner reaction tube or tubes are completely inside the heating chamber. Furthermore, it is preferred that the outer tube and the reaction tube or tubes are of the same expansion inside the heating chamber, irrespective of whether one or both extend(s) through one or both ends of the heating chamber. However, it is also within the scope of this invention that the outer tube should be arranged only around a chosen part of the reaction tube or tubes in the region of highest stress inside the heating chamber, where there is the highest probability of a tube rupturing under the conditions of high temperature and high pressure. Many

metals are weakened, for example, due to the slow formation of the sigma phase. It has been found that sigma formation in the reaction tubes of tube furnaces is not limited to the region where the tubes are subjected to temperatures resulting in the sigma formation. To the contrary, the sigma phase was also induced in other parts of the reaction tubes, which are normally held at significantly lower temperatures, perhaps because these tube segments were exposed temporarily, but repeatedly to abnormal temperatures as a consequence of anomalies in operation. Consequently it can be desired, according to the invention, to protect only those parts of the reaction tubes that are subjected the most frequently to such anomalies. Therefore, it is logical with respect to the embodiments of the invention that a reaction tube or a part of the reaction tube that is accessible to rupture is enveloped by an outer tube, which is designed flow-tight in relation to the heating chamber.

One or both end(s) of the outer tube can be connected to the atmosphere outside the furnace. Similarly one or both end(s) of the outer tube outside the furnace can contain means that break, such as blow-out stoppers or relatively weak parts, which tear or are pushed down and, as a consequence of a rupture of a reaction tube, allow excessive internal pressure to escape into the atmosphere either at the secured point or through a blow-out line. According to a preferred form of the invention, the inside of the external tube is connected to a first valve in order to interrupt selectively or to control in some other way the flow of flowing reaction partners into the reaction tubes; and said inside of the external tube is connected to a second valve in order to block or to control in some other way the pressurized reaction gases from flowing back into the broken reaction tube. If, therefore, a tube rupture occurs, the broken tube can be automatically and completely isolated individually or in connection with other tubes from the rest of the system. Instead of this, a suitable valve unit can be used to let escaping gases flow out into the atmosphere, or to control only the flow of the flowing hydrocarbons to the reaction tube, while the water vapor or another inert gas that is used can continue to flow. In this way the damping effect of the inert gas can be used efficiently as an additional fallback medium.

According to the preferred embodiment of the invention, the outer tube is provided with means for introducing a gas into the outer tube. Said gas cannot burn and does not support combustion when mixed with the reaction partners. There are also means for holding the gas inside the tube at a desired pressure. The presence of such a gas inside the outer tube is very advantageous, because, when the gas is substantially inert, it neutralizes the reaction partners, which flow out of a broken reaction tube and which are often combustible or explosive. In addition, if the gas in the outer tube is held at a pressure between atmospheric pressure and the pressure in the reaction tube, much of the load on the reaction tube can be removed. The presence of a substantially inert gas in the outer tube also prevents or at least largely reduces the carbonizing, sulfidizing, or sulfatizing of the external wall of the reaction tubes or the formation of nitrides and oxidation scales on the outer walls of the tubes. All of these factors significantly reduce, as well-known, the breaking stress value of thin walled reaction tubes; and their elimination or minimization noticeably increases the service life of the reaction tubes. This holds true especially under conditions of high pressure and high temperature, where the limited working area under such conditions requires that any condition that could interfere with the uniformity of the reaction must be avoided as far as possible. Examples of gases that can be used in the outer tube are water vapor, carbon dioxide, waste gases with low oxygen content, nitrogen, and argon.

The position of the inner and outer tubes with respect to each other outside the heating zone can be supported and held by fastening their ends to suitable carrier members. The reaction tube can also be carried by ribs, which are disposed between the inner and outer tubes and are thereby connected together. Similarly the reaction tubes themselves can be built with internal reinforcing parts, which are disposed lengthwise in said tubes and are fastened on the insides of the tubes.

Whereas heat can be fed through arbitrary suitable and known means to the interior of the furnace, the use of spatially separated gas burners, according to US reissue 21 521, is preferred, because this special type of heating means has a heating chamber or zone, in which an automatic control can be carried out.

The general description of the invention below is followed by a more detailed description of yet other different special embodiments for the purpose of explaining the invention with reference to the drawings, where identical reference numerals always refer to the same parts.

Figure 1 is in part a sectional view and in part a side view of a preferred embodiment of a tube cracking furnace, according to the invention.

Figures 2, 3, 4, and 5 are schematic views of additional embodiments of tubes, which can be used according to the invention.

Figures 6, 7, and 8 are sectional views of other embodiments of tubes, which can be used according to the invention.

According to Figure 1 of a preferred embodiment of the invention, a furnace 10 is built of refractory bricks. Outer metallic tubes 11, which are hung on a plurality of springy carrying means, like the carrying means 12, run lengthwise through the heating chamber of the furnace 10. These carrying means are connected to flanges 13, which are attached to the outer surface of the tubes 11. Flow-tight connections are provided through the top furnace wall by means of the sealing rings 14 and the asbestos sealing rings 15. Concentrically inside each external tube 11 is a reaction tube 16 made of a steel alloy. The reaction tube 16 is supported by means of a weld 17, which connects the tubes 11 and 16 in a flow-tight relationship above the furnace roof 18. The top end of each reaction tube 16 is sealed by means of a gasket 19. The bottom ends of the outer tubes 11 and reaction tubes 16 are sealed off and held in position by means of a fluted plate 20 and bolt 21. The annulus 22, formed between the outer tube 11 and the inner reaction tube 16, is connected to an outflow tube 23 by means of a flexible metallic line 24. The outflow tube 23 is supported by a supporting member 25 and is connected to both rows of outer tubes 11. In the top end of the outflow tube 23 there is an adjustable pressure relief valve 26. A line 27 connects the outflow tube 23 to a controller 28, the effect of which will be described below.

The inlet lines 29 guide the flowing reaction partners into the top parts of the reaction tubes 16. A pressure-actuated shut-off valve 30 is disposed in every inlet line 29 and is connected to the controller 28 by means of the line 31. The bottom ends of the reaction tubes 16, which project from the furnace hearth 32, are connected to distributors 33 by means of the lines 34. In each of the lines 34 there is a pressure-actuated shut-off valve 35, which is also connected to the controller 28 by means of the lines 36 and 31. The bottom end of each of the external tubes 11 is equipped with an expansion joint 37. The ends of the external tubes 11 and the reaction tubes 16, which extend below the furnace hearth 32, are enveloped in the insulating shells 38. The lines 39 run to the annulus 22 between the external tubes 11 and the reaction tubes 16 and are used for the introduction of a non-combustible gas, which does not support combustion, into the annulus. The lines 39 can also be used to clean, if desired, the annulus 22.

The valve 30 can be arranged to control only a flowing, combustible reaction partner, whereas it permits an inert or steaming fluid, e.g. water vapor, to continue to flow. In the same way valve 35 can serve to completely shut off or it can be arranged to cut off the defective tube from the downwardly flowing pressurized gas and to connect to the atmosphere those parts of the pressure system that exhibit upward flow. The valves 30 and 35 can be disposed as shown or at selected points in the pressure system, in order to act, as described above. The controller 28 can be an electric or mechanical unit, of which a plethora of types are available. In addition to the above described functions, it can be used to control the main charge and the main performance of the entire unit in order to open the outflow lines and to control the pressure-generating units, like the pumps or the compressors.

In operation the furnace 10 is heated initially by suitable means (not illustrated); and the reaction tubes 16 are heated to the desired temperature. The furnace heats the outer walls of the external tubes 11, which in turn heat the reaction tubes 16 by radiation. The annulus 22 is filled with steam or another non-combustible gas or a gas, which does not support the combustion even in a mixture with the reaction partners. Pressurized, flowing reaction partners, e.g. a flowing hydrocarbon and water vapor, are now fed through the inlet lines 29 to the reaction tubes, and the generated reaction gases are removed through the outlet lines 34 to the distributors 33. When a rupture occurs in the reaction tubes 16, the pressure in the annulus 22 increases suddenly between the reaction tube 16 and the external tube 11. This increase in pressure is transferred through the flexible metallic line 24 to the outflow tube 23. The controller 28, which is set to a specific pressure, actuates the valves 30 and 35 in the inlet line 29 and the outlet line 34. Then the inlet line 29 and the outlet line 34 are closed with or without blowing out; and the ruptured reaction tube is isolated from the rest of the system. The adjustable valve 26 is set to blow out excessive pressures, before the external tube 11 is damaged. If desired, the gas, introduced into the annulus 22, can be held at an arbitrary suitable pressure in order to absorb a part of the load from the pressurized reaction tube 16.

In Figure 2 a reaction tube 50 is arranged concentrically inside a longer external tube 51. Both the reaction tube 50 and the external tube 51 are hung in a heating chamber 52 by means that are identical to those described in Figure 1. The reaction tube 50, the external tube 51 and the heating chamber 52 are all sealed off from one another so as to be flow-tight. Flowing reaction partners are conveyed at the top through the inlet line 53 into the reaction tube 50; and the reaction products are removed at the bottom from the reaction tube 50 through the outlet line 54. The lines 55 and 56 are connected to the annulus 57 between the reaction tube 50 and the external tube 51. A substantially inert gas can be introduced into the annulus 57 either through the line 55 or 56 and can be held at any desired temperature. The annulus 57 can also be cleaned by sending an inert gas into one of the lines 55 and 56 and out the other line. An outflow line 58 with a pressure relief valve 59 runs from the annulus 57 to the atmosphere. Instead of this, the outflow line 58 can be connected to a controller, as described in Figure 1.

According to Figure 3, a reaction tube 60 runs completely through a heating chamber 61. An outer tube 62 is arranged concentrically around a part of the reaction tube 60 and also extends through the upper wall of the heating chamber 61. The reaction tube 60, the heating chamber 61 and the external tube 62 are all sealed off from each other so as to be flow-tight. Flowing reaction partners are fed at the top through the inlet line 63 into the reaction tube 60; and the reaction products are removed at the bottom from the reaction tube 60 through the outlet line 64. Lines 65 and 66 are connected to the annulus 67 between the reaction tube 60 and the external tube 62. A

substantially inert gas can be introduced into the annulus 67 either through the line 65 or 66 and can be held at any desired pressure. The annulus 67 can also be cleaned by sending an inert gas into one of the lines 65 or 66 and out the other. An outflow line 68 with a pressure relief valve 69 runs from the annulus 67 to the atmosphere. Instead of this, the outflow line 68 can also be connected to a controller, as described in Figure 1.

According to Figure 4, a single reaction tube 70 is arranged concentrically inside a shorter outer metallic tube 71. Both of the tubes 70 and 71 run completely through a heating chamber 72. The closed end of the reaction tube 70 extends a short distance beyond the end of the external tube 71; and both are connected together so as to be flow-tight. The annulus 73 between the tubes 70 and 71 is closed at the upper end of the external tube 71 by a fragile disk 74, which is broken at a predetermined pressure inside the annulus 73. Below the heating chamber 72 a ring-shaped corrugated member 75 is attached to the bottom end of the outer tube 71 and to the outer surface of the reaction tube 70 so as to form a sealed connection. The corrugated part 75 allows for a certain variation in the expansion between the reaction tube 70 and the external tube 71. The lines 76 and 77 are connected to the annulus 73 between the reaction tube 70 and the external tube 71. A substantially inert gas can be introduced through one of the lines 76 and 77 into the annulus 73 and held at a desired pressure. The annulus 73 can also be cleaned by sending an inert gas into the chamber through one of the lines 76 and 77 and out again through the other line.

Pressurized flowing reaction partners are fed through the inlet line 78 to the top end of the reaction tube 70. The flowing reaction partners pass through the tube 70 and react in the area surrounding the heating chamber 72. The generated gases are removed from the floor of the reaction tube through an outlet line 79. When the reaction tube 70 breaks, the gases flow from the reaction tube 70 into the annulus 73 between the reaction tube 70 and the external tube 71. At a predetermined pressure the disk 74 tears, and the gases escape into the atmosphere or through an especially provided discharge line (not illustrated).

Figure 5 shows a modification of the tube, depicted in Figure 1. In the device of Figure 5, a reaction tube 80, a reaction tube 81 and an external tube 82 are arranged concentrically and run completely through a heating chamber 83. The three tubes are connected together above the heating chamber 83 so as to be flow-tight. Below the heating chamber 83 the external tube 82 is connected flow-tight to the outer reaction tube 81 by means of a ring-shaped corrugated member 84; and the outer reaction tube 81 in turn is connected flow-tight to the inner reaction tube 80 by means of a ring-shaped corrugated member 85.

Pressurized flowing reaction partners are introduced through the feed line 86 into the inner reaction tube 80. A pressure shut-off valve 87 is disposed in the feed line 86. The same or different pressurized, flowing reaction partners are introduced into the outer reaction tube through the feed line 88, in which a pressure shut-off valve 89 is disposed. A discharge line 90 runs from the annulus 91 between the external tube 82 and the reaction tube 81 to a controller 92. The device 92 and the valve 89 are connected by means of the line 93. The lines 94 and 95 are connected to the annulus 91 between the outer reaction tube 81 and the external tube 82. A substantially inert gas can be introduced into the annulus 91 either through the line 94 or 95. The annulus 91 can also be cleaned by sending an inert gas into the annulus through one of the lines 94 and 95 and out through the other line. Below the heating chamber 83 runs an outlet line 96 from the outer reaction tube 81 through the valves 97 and 98. An outlet line 99 runs from the bottom end of the inner reaction tube 80 through a valve 100. The controller 92 is connected to the inlet valves 87 and 89 by means of the lines 101 and 93. The controller 92 is connected to the

outlet valve 89 by means of the line 102 and to the outlet valve 100 by means of the lines 102 and 103. The valve 97 in line 96 is also connected to the controller 92 by means of the line 104.

If while operating the device, shown in Figure 5, the outer reaction tube 81 bursts, internal pressure develops in the annulus 91 between the external tube 82 and the outer reaction tube 81. At a specific pressure the controller 92 is actuated; and pressurized gas can flow out of the annulus 91 into the lines 93, 101, 102 and 103 in order to close the inlet valves 89 and 87 or the outlet valves 98 and 100. If, on the other hand, the reaction tube 80 bursts, the pressure in the reaction tube 81 either increases or falls as a function of the relative pressures maintained in the tubes 80 and 81. At a predetermined pressure in the tube 81, the valve 97 in the outlet line 96 actuates the controller 92; and pressurized gas can flow out of tube 81 through the line 104, the controller 92 and the lines 93, 101, 102 and 103 in order to close, as described above, the inlet valves 87 and 89 and the outlet valves 98 and 100. As a consequence, irrespective of which reaction tube bursts, the concentric arrangement of the reaction tubes prevents the combustible and/or explosive gases from leaving the interior of the furnace. As explained with respect to the other tube units, a substantially inert gas, like nitrogen, carbon dioxide or water vapor, can be introduced into the annulus 91 and held at an arbitrary desired pressure.

Figure 6 depicts a modification of the tube unit, according to the invention, where three reaction tubes 110 are separated lengthwise from each other in an external tube 111 and are disposed in the inside wall of the external tube. The reaction tubes 110 are heated by means of radiation from the external tube 111, which in turn is heated, as described for Figure 1, by means of a furnace.

According to Figure 7, a single reaction tube 120 is arranged concentrically inside an external tube 121. In addition to arbitrary supporting means, used at each end of the tube, ribs 122 are arranged lengthwise between the outer surface of the tube 120 and the inner surface of the tube 121. These ribs reduce the consumption of the reaction tube 120 during usage and serve, therefore, to reduce the stresses in the grouping. The ribs 122 can be independent parts, which are attached to the outside of the tube 120 or to the inside of the external tube 121 or to both. Instead of this, the tube 120 or the tube 121 can also be cast with perpendicular ribs as one continuous part; or the entire structure of tube 120, tube 121 and ribs 122 can be cast as one piece.

In Figure 8 a reaction tube 130 is arranged concentrically inside an external tube 131. The ribs 132 are attached between the tubes 130 and 131. The reaction tube 130 is divided into compartments by means of a cross-shaped member 133, where each end of the cross is fastened to the inside wall of the tube 130. The inner tube can be made by casting as a single piece or, if desired, can be made of separate segments in any arbitrary way. The member 133 serves to reinforce the reaction tube 130 and to enlarge the heat-transferring surface. Parts can be used that divide the reaction tube into an arbitrary number of compartments, provided the result is not a deleterious resistance for the gas flow. As in the case of the tube, depicted in Figure 7, the construction, shown in Figure 8, can be cast as a continuous unit.

Therefore, it is clear that a tube furnace, according to the invention, makes it possible to treat flowing reaction partners, e.g. hydrocarbons, at high temperature and high pressure with greater safety. In the meantime, the arrangement of one or more reaction tube(s) inside an external tube, according to the invention, should not be regarded as advantageous only with respect to a safety measure. In the case of the tube reaction furnace, according to the invention, the service life of the reaction tubes is significantly increased, because the heating of the reaction tubes by means of radiation from the outer tubes is significantly more uniform than in the prior

art devices, where the reaction tubes are heated directly. Even if the heat, delivered to the external tube, is somewhat irregular, this tube serves to equalize during the transfer of heat; and the anomalies, acting from the outside on the external tube, are distributed in order to induce a smooth flow of radiant heat onto the reaction tubes. If work is done at high pressure and high temperature, a uniform tube temperature is very desired, because the safety range between breaking stress values at a given operating temperature is often narrow. Furthermore, the external tube acts as a buffer and protects the pressure reaction tubes from damage, which usually results from irregularities in heating and the impact of flames, which contribute significantly to inducing the tubes to break in tube furnaces that are used in the conventional manner. In addition, the external tube protects the neighboring tubes from the impingement of liquid jets and the impact of flames, which have resulted to date from the rupture of a neighboring tube and which lead quickly to the rupture of the neighboring tubes under the conditions of high temperature and high pressure.

If the combustion gases contain sulfur, the outer tube protects the reaction tubes from sulfur corrosion. If, as preferred, the external tube contains an inert gas, the formation of oxidic scales on the reaction tube is eliminated or at least reduced to a minimum.

An additional advantage, apart from the device itself and the avoidance of the danger of explosion, lies in the circumstance that the trouble and risk for the operating personnel owing to the adverse effect of gases with low oxygen content or carbon monoxide-containing gases on the atmosphere can be entirely eliminated.

The tubes, used according to the invention, can be made of the selected, currently used materials, with which the longest application in operation can be obtained according to the current knowledge of technology. The reaction tubes of tube furnaces have generally been made of an austenitic steel. Metal type 310 is largely used; and some cast steel tubes have been used. Metal type 310, stabilized with about 1% niobium (columbium), is a preferred metal for the manufacture of tubes, according to the invention. The addition of about 3 to 6% tungsten yields greater strength.

Whereas most tube furnaces use perpendicularly arranged reaction tubes and the invention was explained in particular with reference to embodiments, in which the reaction tubes and the external tubes are arranged perpendicularly, the invention is not limited at all to perpendicularly arranged tubes. In fact, it is obvious to the person skilled in the art that the reaction tubes in the heating chamber can also be arranged horizontally or diagonally and be present in rows of U-shaped arcs or coils.

The illustrated ring-shaped, corrugated parts and expansion joints are made preferably of a metal, which is stable to scaling, in such a manner that the construction has adequate elasticity to balance the differences in expansion among the tubes. However, the invention is not limited to the use of ring-shaped, corrugated metal parts. Even though such corrugated expansion joints are preferred, other known methods for balancing the expansion differences can also be used.

It is also within the scope of the invention that flowing reaction partners can be fed to the reaction tubes by means of suitable distributors in place of individual feed lines, as shown in the figures.

The device, according to the invention, can be used either for catalytic or non-catalytic reactions, or, if a plurality of reaction tubes are used, as shown in Figures 5 and 6, then catalytic and non-catalytic reactions can be carried out simultaneously in the different tubes of the same device. If a furnace, according to the invention, is used for a catalytic reaction, then the catalyst

can be placed in any known suitable way in the reaction tubes. Whereas furnaces, according to the invention, can be used primarily for the treatment of flowing hydrocarbons and especially for the recovery of hydrogen, synthesis gas and olefin-containing gas by means of catalytic and non-catalytic treatment of flowing hydrocarbons, the invention can be used in general for the treatment of flowing reaction partners.

For example, the furnace, according to the invention, can be used advantageously for reactions, like the production of acetic anhydride from acetic acid, the production of ketene by splitting acetone and for various Fischer-Tropsch synthesis reactions.

Patent Claims:

1. Tube reaction furnace for the treatment of pressurized, flowing reaction partners, characterized in that the said tube reaction furnace comprises the combination of the following features: comprising a heating chamber; comprising at least one oblong metallic reaction tube in the heating chamber; comprising at least one outlet metallic tube, which is arranged around at least one essential part of the reaction tube in the region of highest stress inside the heating chamber, said external tube being designed flow-tight in relation to the reaction tube and the heating chamber; comprising inlet means for delivering pressurized flowing reaction partners to each reaction tube; and comprising outlet means for removing the pressurized reaction products from each reaction tube.

2. Furnace, as claimed in claim 1, characterized in that it has a line for introducing a non-combustible gas, which does not support combustion, into the external tube, and that it has a device in order to hold this gas under pressure inside the external tube.

3. Furnace, as claimed in claim 1 or 2, characterized in that the external tube and the reaction tube extend completely through the heating chamber.

4. Furnace, as claimed in claim 3, characterized in that one end of the external tube is sealed, and the other end is connected to the atmosphere.

5. Furnace, as claimed in claim 3, characterized in that one end of the external tube is sealed, and the opposite end has pressure relief means.

6. Furnace, as claimed in claim 3, characterized in that both ends of the external tube are sealed and the inside of the external tube is connected to a first valve in order to selectively interrupt the flow of flowing reaction partners into the reaction tube; and that said inside is connected to a second valve in order to prevent the reaction product from flowing backwards into the reaction tube, where the external tube is connected to a line for introducing a non-combustible gas, which does not support combustion, into the external tube and to a device for maintaining this gas under pressure inside the external tube.

7. Furnace, as claimed in any one of the preceding claims, characterized in that a plurality of reaction tubes are arranged inside every external tube.

8. Furnace, as claimed in claim 7, characterized in that a plurality of reaction tubes (80, 81) are arranged concentrically inside every external tube.

9. Furnace, as claimed in claims 1 to 6, characterized in that a single reaction tube is arranged concentrically inside every external tube.

To this 1 sheet of drawings

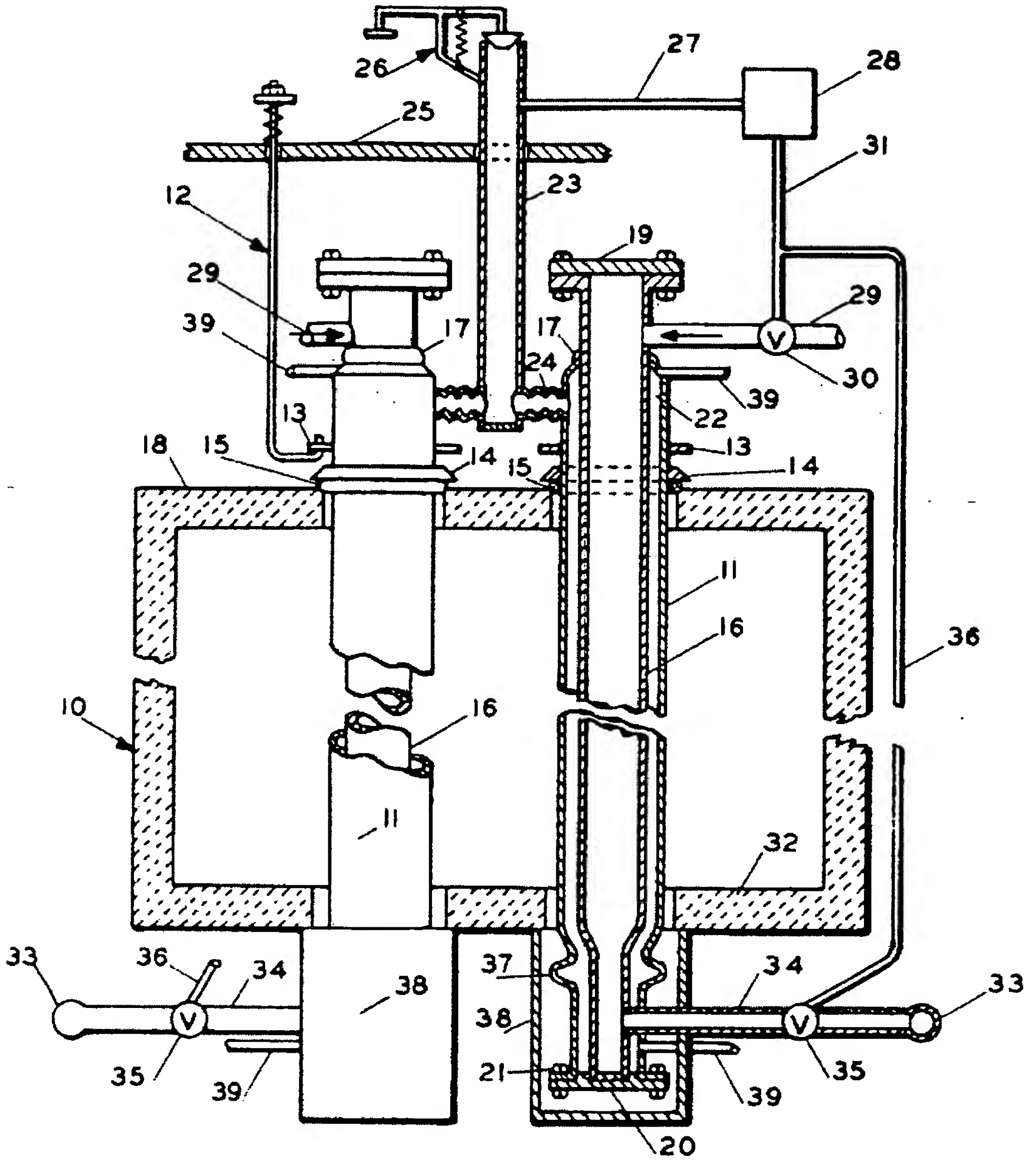

FIG.1

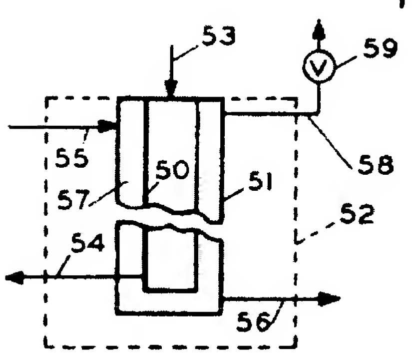

FIG. 2

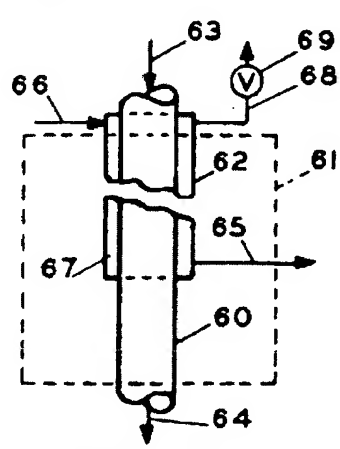

FIG.3

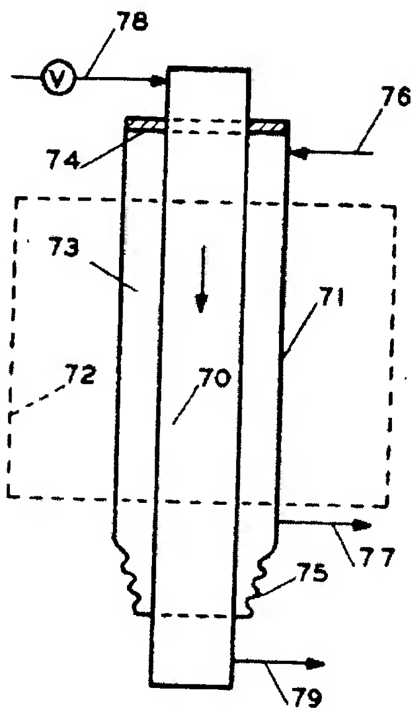

FIG.4

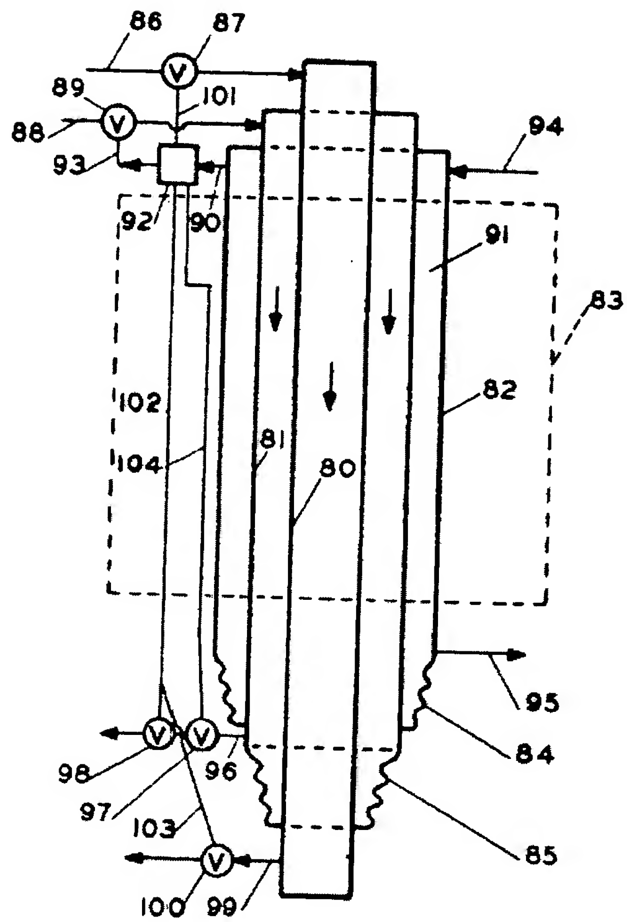

FIG.5

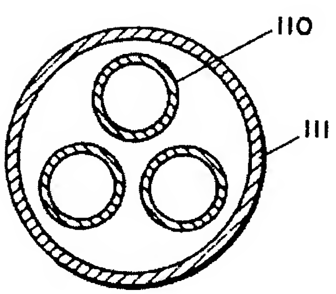

FIG.6

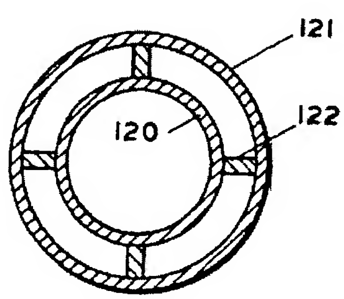

FIG.7

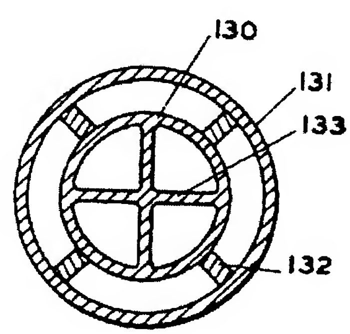

FIG 8